



## Diet of *Didelphis albiventris* Lund, 1840 (Didelphimorphia, Didelphidae) in two periurban areas in southern Brazil

Alexandre Rodrigues da Silva\*, Eduardo Dias Forneck, Sérgio Augusto de Loretto Bordignon and Cristina Vargas Cademartori

Centro Universitário La Salle, Laboratório de Manejo de Fauna, Av. Victor Barreto, 2288, 92010-000, Canoas, Rio Grande do Sul, Brazil.

\*Author for correspondence. E-mail: [alebiologia\\_rs@hotmail.com](mailto:alebiologia_rs@hotmail.com)

**ABSTRACT.** *Didelphis albiventris* Lund, 1840 is one of the least known Brazilian marsupials with respect to its feeding habits. Since the white-eared opossum is omnivorous, it occupies several niches and may be found in urban areas as well as in forest fragments. Current analysis aimed at determining and comparing the diet of *D. albiventris* in two periurban areas of the municipality of Viamão, a conserved forest remnant and a degraded area resulting from agricultural activities. Captures of *D. albiventris* were carried out for a period of 30 months by a sampling effort of 504 trap-nights. Forty fecal samples were collected from 45 captures corresponding to 18 specimens. Diet was determined by fecal analysis. Fruit was the most representative item, at an occurrence of 77.5%, comprising six species of plants, followed by invertebrates (62.5%) and vertebrates (37.5%). *Didelphis albiventris* displayed a frugivorous-omnivorous habit, with no difference between the sexes with respect to composition and frequency of the items consumed. Since there was a greater diversity of food items and fruits in the more conserved area, seasonal variations in the diet could be detected. Generalist species, such as *D. albiventris*, may have an important role in the recovery of degraded areas through the dispersal of seeds of species of initial successional stages.

**Keywords:** white-eared opossum, feeding habits, frugivory, Atlantic Forest.

## Dieta de *Didelphis albiventris* Lund, 1840 (Didelphimorphia, Didelphidae) em duas áreas periurbanas no Sul do Brasil

**RESUMO.** *Didelphis albiventris* Lund, 1840 é um dos marsupiais brasileiros menos conhecidos quanto aos hábitos alimentares. De hábito onívoro, ocupa uma variedade de nichos, sendo encontrado tanto em áreas urbanas quanto em fragmentos florestais. Teve-se como objetivo conhecer e comparar a dieta de *D. albiventris* em duas áreas periurbanas do município de Viamão: um remanescente florestal conservado e uma área degradada por atividades agropastoris. Foram efetuadas capturas de *D. albiventris* durante um período de 30 meses, resultando em um esforço amostral de 504 armadilhas-noite. Foram coletadas 40 amostras de fezes decorrentes de 45 capturas correspondentes a 18 indivíduos. A dieta foi determinada através de análise fecal. Com ocorrência de 77,5%, os frutos foram o item mais representativo, compreendendo seis espécies de plantas, seguido de invertebrados, com 62,5%, e vertebrados, com 37,5%. *Didelphis albiventris* apresentou hábito frugívoro-onívoro, não havendo diferença entre os sexos quanto à composição e frequência dos itens consumidos. Na área mais conservada, obteve-se a mais alta diversidade de itens alimentares e de frutos, encontrando-se variações sazonais na dieta. Espécies generalistas, tais como *D. albiventris*, podem desempenhar importante papel na recuperação de áreas degradadas, efetuando a dispersão de sementes de espécies de estádios sucessionais iniciais.

**Palavras-chave:** gambá-de-orelha-branca, hábitos alimentares, frugivoria, domínio da Mata Atlântica.

### Introduction

Marsupials currently exist in only two regions of the world, on the Australian and American continents (REDFORD; EISENBERG, 1992). They are considered small- to medium-sized animals which may occupy a variety of habitats. In fact, they are widely represented and distributed throughout the Neotropical region, mainly in forest environments (EMMONS; FEER, 1997).

Marsupials are extremely diversified animals with regard to their habits, with a predominantly omnivorous diet, although many researchers attribute the feeding tendencies of frugivory, insectivory and carnivory to the group (SANTORI; ASTÚA DE MORAES, 2006). Thus, they perform important ecological functions, such as controlling populations of vertebrates and invertebrates, and dispersing seeds (BARBOSA et al., 2012). In tropical

forests, endozoochory is the principal form of seed dispersal, which reveals an important interaction between plants and animals (CHARLES-DOMINIQUE, 1986). According to Uhl (1997) and Jordano et al. (2006), the conservation and regeneration of different types of vegetation are highly dependent on seed dispersal by mammals.

Didelphid marsupials are traditionally known as small mammals with nocturnal, solitary and generalist diet habits, consuming small vertebrates, invertebrates and fruits (REIS et al., 2006). Among the didelphids, *D. albiventris* is among the least studied species with regard to its feeding habits (SANTORI; ASTÚA DE MORAES, 2006). *D. albiventris* has a wide geographic distribution in South America, where it occurs in various biomes in Brazil, such as the Atlantic Rain Forest, Cerrado, Pantanal, Caatinga and Campos Sulinos (REIS et al., 2009). Since they may be found in small forest fragments and in places with a high degree of ecological disturbances, the white-eared opossums are capable of adapting themselves to fragmented habitats and to those modified by anthropogenic activities (FERNANDEZ; PIRES, 2006). Owing to their frugivorous-omnivorous and generalist habits, they are directly involved in the dispersal of seeds of many plant species (CÁCERES; MONTEIRO-FILHO, 2007), which, according to Cantor et al. (2010), are swallowed whole, with a viability of up to 71% after defecation.

So that knowledge on the still poorly known feeding habits of one species of *Didelphis* could be deepened, current study determined and compared the diet of *D. albiventris* in two periurban areas in southern Brazil, or rather, a more preserved habitat and another altered by agricultural activities. The white-eared opossum is a widespread species which presents a generalist diet, an opportunistic habit, as well as the capacity to occupy disturbed environments. Knowledge on diet of *D. albiventris* might help understand the importance of the species for seed dispersal and, consequently, its role in the restoration of degraded areas.

## Material and methods

### Study Areas

The study was conducted in two areas in the municipality of Viamão, Rio Grande do Sul State, Brazil (Figure 1). One of the areas, known as

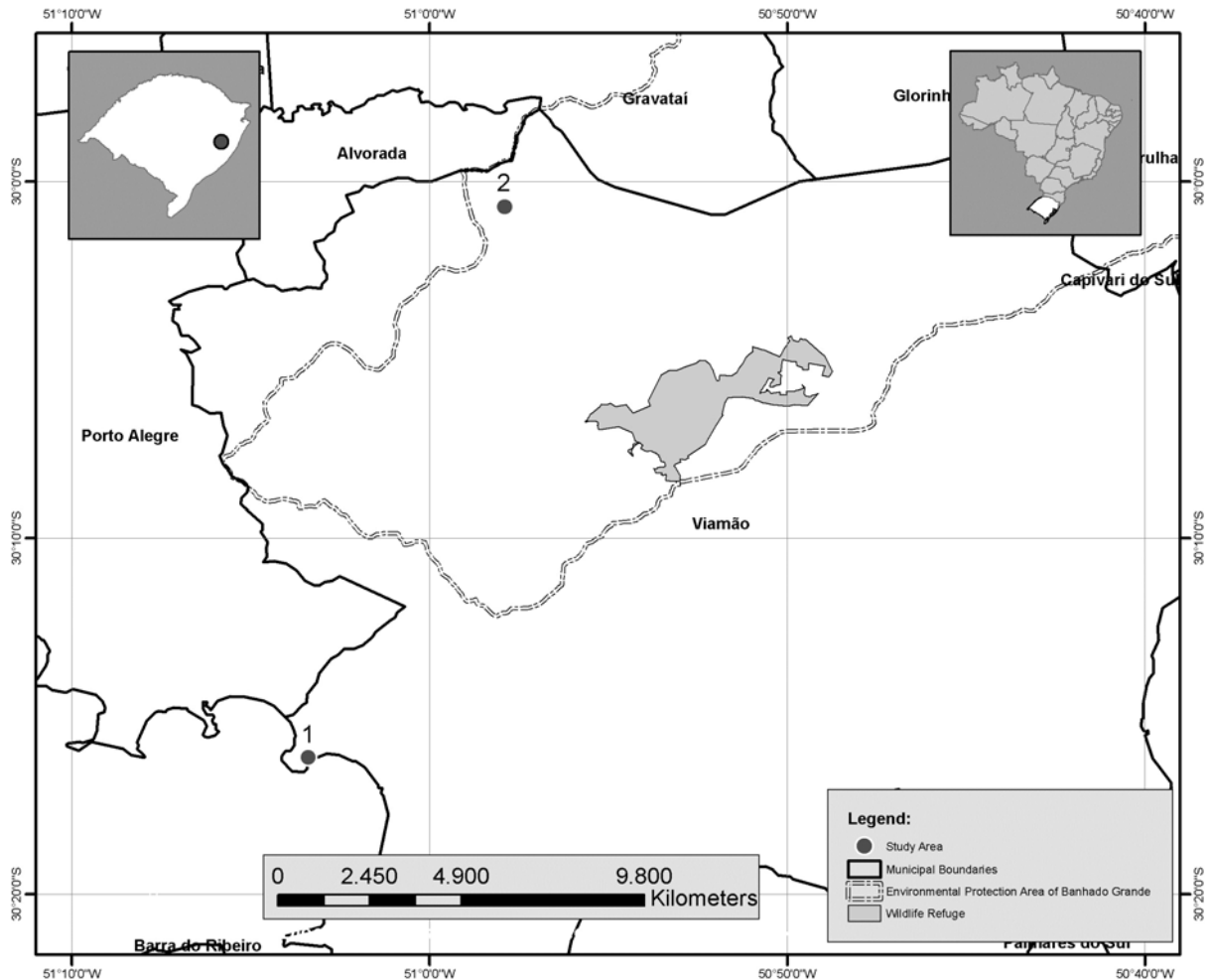
Morro do Coco, is a remnant of a semideciduous seasonal forest, part of the Atlantic Rain Forest (30°16'15"S and 51°02'54"W). The area, covering approximately 142 ha, lies on the edge of Lake Guaíba and is somewhat connected with other forest areas, such as the hills of São Pedro and Extrema, and with conservation units, such as the *Reserva Biológica do Lami José Lutzenberger* and *Parque Estadual de Itapuã*. Its surroundings comprise small farms and ranches and small urban centers.

The other area comprises a rural property close to the boundary of the APA do Banhado Grande (29°58'11.37"S and 50°58'1.34"W). The region is an ecotone characterized by a mosaic of forest formations of the Atlantic Rain Forest (semideciduous seasonal forest), coastal pioneer formations and fields (TEIXEIRA et al., 1986). The area lies close to the river Gravataí, where marshes, fields and remnants of a semideciduous seasonal forest are predominant. It is an area highly disturbed by anthropic impacts, which include houses, ranches, farms, eucalyptus plantations and other city-connected activities, such as hunting, domestic animals and factories.

The region's macroclimate is Cfa type (subtropical humid), according to Köppen's classification, with mean annual temperature at 19.5°C, cold winters with minimum temperature at 3°C, and warm summers with maximum temperature at 41°C; annual rainfall 1347 mm, distributed uniformly throughout the year (MORENO, 1961). There are four distinct seasons (autumn, winter, spring and summer) in the southern State of Rio Grande do Sul, which differ by photoperiod (varying from about 10h on June 21, at the beginning of winter, to 14h on December 21, at the start of summer) and by rain regime and temperature variations (HASENACK; FERRARO, 2006; LIVI, 2006).

### Sampling of Scats

Capture of marsupials of the species *D. albiventris* was carried out with 10 live traps placed on the ground, in the understorey and at the tree stratum (between 1.5 and 6 m high). The traps were set monthly, from one to two consecutive nights, close to fruiting trees and streams, on paths, and inside and on the border of forest remnants. They were checked daily in the morning. The captured animals were labeled with numbered tags and their sex determined (authorizations by SISBIO 12094-2 of 2008 and 24673-2 of 2010).



**Figure 1.** Site of studied areas in the municipality of Viamão, Rio Grande do Sul State, Brazil. 1 – Morro do Coco, a more conserved area; 2 – Land belonging to APA do Banhado Grande, with greater anthropic impact.

In Morro do Coco, the expeditions were conducted from January 2009 to June 2010, and from April to June 2012, totaling 21 months. In APA do Banhado Grande, the samplings covered the period between March and November 2011, totaling nine months. Data collection on the diet of *D. albiventris*, in both areas, totaled 30 months. The capture effort corresponded to 390 trap-nights in Morro do Coco and 114 trap-nights in APA do Banhado Grande. Banana, peanut butter, bacon, sardines and pineapple were used for bait.

#### Diet Analysis

Samples of feces were collected from the floor of the live traps and placed in labeled plastic pots for preparation and laboratory analysis. Each fecal sample consisted of the total feces produced by one specimen in one night. The samples were taken to the laboratory and dried in an oven at 60°C. The fecal content was sorted out and the food items

present in the feces were identified with the help of a stereomicroscope and specialized literature (LORENZI, 1992), as well as on the basis of comparison with reference material collected in the study area.

The frequency of occurrence, which resulted from the ratio between the frequency of the particular item and the total number of fecal samples, evaluated the representativeness of the different items found in the diet. Differences in diet or diet diversity between the two areas were compared by Levin's Standardized Index ( $B_A$ ), which attributed greater weight to food items that were more abundant in the diet, according to Krebs (1998) and Caceres (2002), varying from 0 to 1. Values closer to 1 meant that the items recorded were close to maximum diversity. The significance of the differences found was tested by the non-parametric Kruskal-Wallis (H), Mann-Whitney (U) and chi-squared ( $\chi^2$ ) tests. Yates

correction was applied to the last test for continuity. The Mann-Whitney test was also utilized as post-test coupled to Kruskal-Wallis's test. Differences were considered significant if  $p < 0.05$ . Statistical analysis was carried out with Past 4.01 (HAMMER et al., 2001).

## Results and discussion

In the two areas under analysis, there were 45 captures of *D. albiventris*, of which 33 occurred in Morro do Coco and 12 in APA do Banhado Grande. Fourteen specimens, 8 females and 6 males, among the 45 captures, were recorded in Morro do Coco, and 4 specimens, 2 males and 2 females, in APA do Banhado Grande. Thus, out of the total captures, 27 corresponded to recaptures on different expeditions. As a result, 28 samples of feces were collected in Morro do Coco and 12 samples in APA do Banhado Grande, totaling 40 samples. Therefore, five samples were discarded to ensure independence of data since they were obtained from specimens recaptured in the same expedition.

*Didelphis albiventris* showed a varied diet, composed of vertebrates, invertebrates and fruits, although fruits and arthropods were the main items in the diet, when the combined samples of the two areas are taken into consideration (Table 1). Males and females did not differ significantly with respect to the composition and frequency of the items consumed ( $U = 50.5$ ;  $p = 0.2237$ ), as reported by Cantor et al. (2010) and by Cáceres et al. (2009) and Ceotto et al. (2009) for *D. aurita*. Seeds, rhizomes, grasses and fibers of *Syagrus romanzoffiana* (Cham.) Glassman, representing items of plant origin, were the most frequent food items in the diet and comprised 77.5% of the samples. Invertebrates were the second most found item in 62.5% of the fecal samples, followed by vertebrates (37.5%). Cáceres (2002) obtained a similar result in forest fragments with araucaria in a periurban region in the State of Paraná, Brazil, although invertebrates were the main food item found in the feces of *D. albiventris*, followed by fruits and vertebrates. Consequently, the diet of *D. albiventris* was predominantly frugivorous-omnivorous, as observed in other studies (CÁCERES, 2002; CASSELA; CÁCERES, 2006; CANTOR et al., 2010). The method of analysis of fecal content proved to be efficient to identify most items in the feces of *D. albiventris*, corroborating results obtained by other authors (CÁCERES, 2002; CÁCERES; MONTEIRO-FILHO, 2001, 2007; CÁCERES et al., 2009).

**Table 1.** Relative (in percentage) and absolute (between parentheses) frequency of food items recorded in 40 fecal samples of *Didelphis albiventris* in two periurban areas of the municipality of Viamão, Rio Grande do Sul State, Brazil, from January 2009 to June 2012. n.i. = taxon not identified.

Food items	Morro do Coco (N = 28)	APA do Banhado Grande (N = 12)	Total (N = 40)
Invertebrates	68 (19)	50 (6)	62.5 (25)
Hymenoptera	46 (13)	50 (6)	47.5 (19)
Coleoptera	18 (5)		12.5 (5)
Diplopoda	7 (2)		5 (2)
Vertebrates	46 (13)	17 (2)	37.5 (15)
Mammalia	32 (9)	8 (1)	25 (10)
Aves	18 (5)	8 (1)	15 (6)
Fruits	86 (24)	58 (7)	77.5 (31)
<i>Syagrus romanzoffiana</i>	29 (8)	50 (6)	35 (14)
<i>Coussapoa microcarpa</i>	29 (8)	8 (1)	22.5 (9)
<i>Ficus cestrifolia</i>	29 (8)		20 (8)
<i>Ficus luschnathiana</i>	4 (1)	17 (2)	7.5 (3)
<i>Cereus hildimannianus</i>	11 (3)		7.5 (3)
<i>Solanum</i> sp.	4 (1)		2.5 (1)
Vegetative parts of plants		25 (3)	7.5 (3)
Asteraceae		8 (1)	2.5 (1)
Poaceae		8 (1)	2.5 (1)
Rhizomes n.i.		8 (1)	2.5 (1)

The diversity of food items differed between the two study areas and was higher in Morro do Coco ( $B_A = 0.6208$ ), the more preserved area, when compared to that of APA do Banhado Grande ( $B_A = 0.3223$ ). In fact, there was a high intake of fruits (82%) and arthropods (68%), whereas the occurrence of these items in the degraded area was lower. The landscape of Morro do Coco comprised more forest environments, surrounded by conservation units and better conserved areas, which implied the availability of a wider variety of resources and justified a more diverse and predominantly frugivorous diet. The area inside APA had received a greater impact of anthropogenic activities, leading to a matrix with more fields than forests and, consequently, a less frugivorous diet. Nonetheless, differences in sampling effort could also have contributed to this result. Although fruit diversity in the fecal samples from Morro do Coco ( $B_A = 0.6286$ ) was about three times greater than in the impacted area ( $B_A = 0.1951$ ) belonging to APA do Banhado Grande, the occurrence of fruits, in relation to occurrence of other different items in the scats, did not differ significantly between the two areas ( $\chi^2 = 2.212$ ,  $df = 1$ ;  $p = 0.1369$ ). Opossums fed mainly on fruits in both areas (86 and 58% occurrence in scats, respectively, according to Table 1).

In Morro do Coco, seeds of five plant species were found in 75% of the samples. Seeds of *Ficus cestrifolia* Schott ex Spreng. and *Coussapoa microcarpa* (Schott) Rizzini were the most frequent in samples from Morro do Coco (29% occurrence for both species). *Cereus hildimannianus* K. Schum. was the second highest occurrence (11%), while *Solanum* sp.

and *Ficus luschnathiana* (Miq.) Miq. seeds were the least frequent in the samples analyzed (both with 4% occurrence). The large seeds of *S. romanzoffiana* were recorded only through the fibers present in the feces, with a 29% frequency. Perhaps the seeds had been expelled near the parent tree, as reported by Charles-Dominique et al. (1981) in a study on the diet of marsupials. In their evaluation on the interaction between *S. romanzoffiana* and local fauna, Silva et al. (2011) suggested that *Didelphis aurita* could disperse palm seeds by moving them at least over short distances during pulp removal. In APA do Banhado Grande, arthropods and fibers of the fruit of *S. romanzoffiana* were the most common items, occurring in 50% of the samples. Seeds had only 25% frequency where the only seeds recorded were those of *F. luschnathiana* and *C. microcarpa* (17 and 8% occurrence, respectively). Vegetative and reproductive parts of Poaceae and Asteraceae were found exclusively in this area, a fact also cited by Cáceres (2002) for both *D. albiventris* and *D. aurita*, in fragmented areas of mixed ombrophilous forest in southern Brazil.

Although *D. albiventris* has a generalist diet that includes a great variety of food items, its importance in fruit intake (CHARLES-DOMINIQUE et al., 1981; CÁCERES; MONTEIRO-FILHO, 2001; CÁCERES, 2002) and its likely influence on seed dispersal (CANTOR et al., 2010) are gradually being acknowledged. However, little is known about the germination of seeds that pass through the intestinal tract. It is known that the germination of some seeds is facilitated by their passing through the intestinal tract of vertebrates, or rather, break of dormancy, reduction of pulp and fertilization by fecal matter (ROBERTSON et al., 2006; TRAVESET, 1998). Cáceres and Monteiro-Filho (2000) showed that most seeds remained intact after being ingested by *D. aurita*. Further, Cantor et al. (2010) found that most seeds were small sized and came from berry or drupaceous fruits with many seeds. In current analysis, seeds found in both study areas corroborated the above results, since most, besides being small-sized, remained whole after passing through the digestive tract. The smallest were the *Ficus* spp. seeds, which measured only 0.5 mm, while the largest, *C. hildimannianus* seed, measured approximately 4 mm. It should be noted, however, that breaking dormancy did not seem to be the greatest advantage for zoochoric plants. According to Jordano et al. (2006), the dispersal of seeds, a process that involves the removal and displacement of seeds from the vicinity of the parent plant to locations where predation and competition are lower, is fundamental in the life cycle of most plants, especially in tropical ecosystems.

*Didelphis albiventris* is the least studied of marsupial species with respect to its feeding habit. Although it is known that its diet includes 21 fruit species (CÁCERES, 2006), only *S. romanzoffiana* and *Solanum* sp., out of all the species of fruits mentioned in current study, are cited in the survey carried out by Cáceres (2006) for *D. albiventris*. Meanwhile, *C. microcarpa* and *Ficus* spp. were recorded in the diet of other marsupials by the same author. *Cereus hildimannianus* (Cactaceae), however, was not mentioned in any other study on the diet of marsupials and was recorded here for the first time.

Cáceres (2002) demonstrated that more than half the fruits consumed by *D. albiventris* were from pioneer plants. Of the six species of fruits recorded in the samples from the two areas, *Solanum* sp., *C. hildimannianus* and *Ficus* spp. are considered pioneer (CHARLES-DOMINIQUE, 1986; FLEMING, 1986). Fig trees, particularly, are protected by law in Rio Grande do Sul, because of the numerous interactions that they establish with fauna and flora (especially epiphytes). Another relevant factor concerns the reporting of seeds of flora species only native to the state, although there are orchards with exotic fruit trees in the neighborhood of the areas under analysis, which revealed the ecological importance of *D. albiventris* as a disperser of native plant species.

At Morro do Coco, where sampling followed an entire annual cycle, a significant difference in the consumption of items between the seasons of the year ( $H = 12.71$ ;  $p = 0.008267$ ) was detected. Temporal variations in the diet were also found in other studies, generally associated with variations in food availability (CÁCERES et al., 2009; CANTOR et al., 2010; CEOTTO et al., 2009). Autumn differed from the other seasons with regard to the items in the fecal samples of *D. albiventris* and was the period with the highest number of samples collected ( $n = 13$ ) and with the greatest variety of food items. Of the six fruit species recorded in the fecal content, five (*C. microcarpa*, *F. cestrifolia*, *F. luschnathiana*, *C. hildimannianus* and *S. romanzoffiana*) were present during this period, coupled to all invertebrate and vertebrate groups. Marsupials are considered opportunistic frugivores (CÁCERES, 2002; CÁCERES et al., 2009) since they consume resources available in the environment. This fact appears to indicate seasonality in the availability of fruits in the study area. In the semideciduous seasonal forest of the State of Paraná, Brazil, Mikich and Silva (2001) reported a fructification peak during the dry season (May and June), coinciding with autumn. According to Cáceres and Monteiro-Filho (1998), in a study conducted in a remnant of an altered mixed

ombrophilous forest in the State of Paraná, *D. albiventris* and *D. aurita* accumulated body fat during autumn to endure winter, during which they lose weight. Although in current study winter was the period with fewer samples collected ( $n = 3$ ), the samples included 50% of the fruits recorded in the area, including *C. hildimannianus*. Seeds of *Solanum* sp. were found exclusively in summer.

## Conclusion

*Didelphis albiventris* showed a frugivorous-omnivorous habit although fruits constituted an important part of their diet, both in diversity and frequency.

The highest diversity of food items in Morro do Coco, especially fruit diversity, indicates the good state of conservation of the area, comprising a more forested landscape, thereby offering a larger variety of resources. Accordingly, the frequency and biomass of other items such as seeds, arthropods and vertebrates were also higher in this area.

The greatest consumption of fruits and, consequently, the highest occurrence of seeds in the fecal samples of the individuals captured in Morro do Coco, revealed the importance of *D. albiventris* in the area, as a disperser of plant species of initial successional stages. Generalist species, such as *D. albiventris*, which are capable of adapting themselves to fragmented landscapes, might help in the regeneration of vegetation by the dispersal of seeds and thus have an important role in degraded areas, where specialized frugivores are absent.

## Acknowledgements

We would like to thank the team that helped us with field work, as well as the Irmãos Lassalistas and Mr. Aristo's family for allowing us to carry out the work on their land. Thanks are also due to CNPq for its financial support and to Unilasalle for the Scientific Initiation Fellowship and logistic support. Diego Medeiros and Regis Waskow of the Laboratório de Geoprocessamento do Unilasalle prepared the map.

## References

- BARBOSA, J. M.; EISENLOHR, P. V.; RODRIGUES, M. A.; BARBOSA, K. C. Ecologia da dispersão de sementes em florestas tropicais. In: MARTINS, S. V. (Ed.). **Ecologia de florestas tropicais do Brasil**. 2. ed. Viçosa: UFV, 2012. p. 85-101.
- CÁCERES, N. C. Food habits and seed dispersal by the White-Eared Opossum, *Didelphis albiventris*, in southern Brazil. **Studies on Neotropical Fauna and Environment**, v. 37, n. 2, p. 97-104, 2002.
- CÁCERES, N. C. O papel de marsupiais na dispersão de sementes. In: CACERES, N. C.; MONTEIRO-FILHO, E. L. A. (Org.). **Os marsupiais do Brasil: biologia, ecologia e evolução**. Campo Grande: UFMS, 2006. p. 255-269.
- CÁCERES, N. C.; MONTEIRO-FILHO, E. L. A. Population dynamics of the common opossum, *Didelphis marsupialis* (Mammalia, Marsupialia), in southern Brazil. **International Journal of Mammalian Biology**, v. 63, p. 169-173, 1998.
- CÁCERES, N. C.; MONTEIRO FILHO, E. L. A. The common opossum, *Didelphis aurita*, as a seed disperser of several plants in southern Brazil. **Ciência e Cultura**, v. 52, p.41-44, 2000.
- CÁCERES, N. C.; MONTEIRO FILHO, E. L. A. Food habits, home range and activity of *Didelphis aurita* (Mammalia: Marsupialia) in a forest fragment of southern Brazil. **Studies on Neotropical Fauna and Environment**, v. 36, n. 2, p. 85-92, 2001.
- CÁCERES, N. C.; MONTEIRO-FILHO, E. L. A. Germination in seed species ingested by Opossums: implications for seed dispersal and forest conservation. **Brazilian Archives of Biology and Technology**, v. 50, n. 6, p. 921-928, 2007.
- CÁCERES, N. C.; PRATES, L. Z.; GHIZONI-JR, I. R.; GRAIPEL, M. E. Frugivory by the black-eared opossum *Didelphis aurita* in the Atlantic Forest of southern Brazil: roles of sex, season and sympatric species. **Biotemas**, v. 22, n. 3, p. 203-211, 2009.
- CANTOR, M.; FERREIRA, L. A.; SILVA, W. R.; SETZ, E. Z. F. Potential seed dispersal by *Didelphis albiventris* (Marsupialia, Didelphidae) in highly disturbed environment. **Biota Neotropica**, v. 10, n. 2, p. 45-51, 2010.
- CASSELLA, J.; CÁCERES, N. C. Diet of four small mammal species from Atlantic Forest patches in southern Brazil. **Neotropical Biology and Conservation**, v. 1, n. 1, p. 5-11, 2006.
- CEOTTO, P.; FINOTTI, R.; SANTORI, R.; CERQUEIRA, R. Diet variation of the marsupials *Didelphis aurita* and *Philander frenatus* (Didelphimorphia, Didelphidae) in a rural area of Rio de Janeiro State, Brazil. **Mastozoología Neotropical**, v. 16, n. 1, p. 49-58, 2009.
- CHARLES-DOMINIQUE, P. Inter-relations between frugivorous vertebrates and pioneer plants: *Cecropia*, birds and bats in French Guyana. In: ESTRADA, A.; FLEMING, T. H. (Ed.). **Frugivores and seed dispersal**. New York: Springer-Verlag, 1986. p. 119-134.
- CHARLES-DOMINIQUE, P.; ATRAMENTOWICZ, M.; CHARLES-DOMINIQUE, M.; GERARD, H.; HLADIK, A.; HLADIK C. M.; PRÉVOST, M. F. Les mammifères frugivores arboricoles nocturnes d'une forêt guyanaise: interrrelations plantes-animaux. **Revue d'Ecologie Terre et Vie**, v. 35, n. 3, p. 341-435, 1981.
- EMMONS, L. H.; FERR, F. **Neotropical rainforest mammals: a field guide**. 2nd ed. Chicago/London: The University of Chicago Press, 1997.
- FERNANDEZ, F. A. S.; PIRES, A. S. Perspectivas para a sobrevivência dos marsupiais em fragmentos florestais: o

- que sabemos e o que ainda precisamos aprender? In: CACERES, N. C.; MONTEIRO-FILHO, E. L. A. (Org.). **Os marsupiais do Brasil: biologia, ecologia e evolução**. Campo Grande: UFMS, 2006. p. 191-201.
- FLEMING, T. H. Opportunism versus specialization: the evolution of feeding strategies in frugivorous bats. In: ESTRADA, A.; FLEMING, T. H. (Ed.). **Frugivores and seed dispersal**. Dordrecht: W. Junk Publishers, 1986. p. 105-118.
- HAMMER, O.; HARPER, D. A. T.; RYAN, P. D. PAST, Paleontological statistics software package for education and data analysis. **Palaeontologia Electronica**, v. 41, n. 1, p. 1-9, 2001.
- HASENACK, H.; FERRARO, L. W. Clima urbano: Ilhas de Calor e ventos fortes na selva de pedra. In: MENEGAT, R.; PORTO, M. L.; CARRARO, C. C.; FERNANDES, L. A. D. (Coord.). **Atlas ambiental de Porto Alegre**. 3.ed. Porto Alegre: UFRGS, 2006. p. 149-150.
- JORDANO, P.; GALETTI, M.; PIZO, M. A.; SILVA, W. R. Ligando frugivoria e dispersão de sementes à Biologia da Conservação. In: ROCHA, C. F. D.; BERGALLO, H. G.; SLUYS, M. V.; ALVES, M. A. S. (Org.). **Biologia da Conservação: essências**. São Carlos: Rima, 2006. p. 411-436.
- KREBS, C. J. **Ecological methodology**. 2nd ed. New York: Addison Wesley Longman, 1998.
- LIVI, F. P. Elementos do clima: contraste de tempos frios e quentes. In: MENEGAT, R.; PORTO, M. L.; CARRARO, C. C.; FERNANDES, L. A. D. (Coord.). **Atlas ambiental de Porto Alegre**. 3.ed. Porto Alegre: Ufrgs, 2006. p. 73-78.
- LORENZI, H. **Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil**. São Paulo: Instituto Plantarum de Estudos da Flora, 1992.
- MIKICH, S. B.; SILVA, S. M. Composição florística e fenologia das espécies zoocóricas de remanescentes de Floresta Estacional Semidecidual no centro-oeste do Paraná, Brasil. **Acta Botânica Brasilica**, v. 15, n. 1, p. 89-113, 2001.
- MORENO, J. A. **Clima do Rio Grande do Sul**. Porto Alegre: Secretaria da Agricultura, 1961.
- REDFORD, K. H.; EISENBERG, J. F. **Mammals of the Neotropics: the southern cone: Chile, Argentina, Uruguay, Paraguay**. Chicago/London: The University of Chicago Press, 1992.
- REIS, N. R.; PERACCHI, A. L.; PEDRO, W. A.; LIMA, I. P. **Mamíferos do Brasil**. Londrina: Nélcio R. Reis, 2006.
- REIS, N. R.; PERACCHI, A. L.; FREGONEZI, M. N.; ROSSANEIS, B. K. **Guia ilustrado mamíferos do Paraná- Brasil**. Pelotas: USEB, 2009.
- ROBERTSON, A. W.; TRASS, A.; LADLEY, J. J.; KELLY, D. Assessing the benefits of frugivory for seed germination: the importance of the deinhibition effect. **Functional Ecology**, v. 20, n. 1, p. 58-66, 2006.
- SANTORI, R. T.; ASTÚA DE MORAES, D. Alimentação, nutrição, e adaptações alimentares de marsupiais brasileiros. In: CACERES, N. C.; MONTEIRO-FILHO, E. L. A. (Org.). **Os marsupiais do Brasil: biologia, ecologia e evolução**. Campo Grande: UFMS, 2006. p. 241-254.
- SILVA, F. R.; BEGNINI, R. M.; LOPES, B. C.; CASTELLANI, T. T. Seed dispersal and predation in the palm *Syagrus romanzoffiana* on two islands with different faunal richness, southern Brazil. **Studies on Neotropical Fauna and Environment**, v. 46, n. 3, p. 163-171, 2011.
- TEIXEIRA, M. B.; COURA NETO, A. B.; PASTORE, U.; RANGEL FILHO, A. L. R. Vegetação. In: SEPLAN/IBGE. **Levantamento dos recursos naturais**. Rio de Janeiro: IBGE, 1986. v. 33, p. 541-642.
- TRAVERSE, A. Effect of seed passage through vertebrate frugivores guts on germination: a review. **Perspectives in Plant Ecology, Evolution and Systematics**, v. 1, n. 2, p. 151-190, 1998.
- UHL, C. Restauração de terras degradadas na Bacia Amazônica. In: WILSON, E. O.; PETER, F. M. (Ed.). **Biodiversidade**. Rio de Janeiro: Nova Fronteira, 1997. p. 419-427.

Received on April 10, 2013.

Accepted on September 18, 2013.

License information: This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.